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DISCOVERY Agriculture

# Discovery of self-reliant regenerative sustainable agricultural model, an "On-Farm" research for higher profit of small & marginal farmers

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**General Note**

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## ABSTRACT

An experiment was conducted in the farmer's field at Moraghata village of Ichhapur Mouza of Balagarh Block under Hooghly district of West Bengal, India (Latitude: 23.18 to Longitude: 88.40) for consecutive three years starting from Rabi 2015-16 to Kharif 2018-19. Seven farmers were included, each under one Model, out of which four were given seeds of fodder crops like Barseem, Oat & Maize during Rabi season and Sorghum, Maize, Cowpea and cutting of Hybrid Napier during Pre-Kharif & Kharif for growing round the year green fodder as per Model. Round the year green fodder was grown by Model 1 farmer in 0.5 bigha/666.7 Sq meter and Model 2, Model 3, Model 4 farmers in 1 bigha/1333.3 sq meter of land. Poly Vermi Pit along with vermin and a family size Biogas Plant were given to the farmers as per requirement of Models. Model 1 farmer grew paddy cv Swarna during Kharif 2016-17@ vermicompost+green manure @ 2.5t/ha each, although he discontinued to practice green manuring during next two years due to mortality of standing green manure crop owing to heavy rain and resultant inundation during first year. Model 2 farmer grew paddy with 6.25 t vermicompost/ha, applied in three splits (50% as basal, 25% 15-20 DAT & 25% at 35-40 DAT), Model 3 applied farm yard manure @ 10 t/ha as basal& Model 4 applied biogas slurry @ 6.25 t/ha, applied in three splits (50% as basal, 25% 15-20 DAT & 25% at 35-40 DAT). Models, where the farmers applied vermicompost or Bioslurry has increased paddy yield over models where recommended dose of fertilizer@ N:$P_2O_5$:$K_2O$ 80:40:40 Kg/ha (model 7) or 75% of the RFD and 2.5 t vermicompost/ha fertilizer (model 5) were applied. Highest profit/ha of Rs 62906.0 was obtained under Model 4, followed by Model 2(Rs 52322.0) and Model 6(Rs 51293.0). Model 1 recorded the lowest profit of Rs 31151.0 followed by model 5(Rs 32432.0).


**Key words:** cost of production, integrated farming system, farmer's profit, improvement of soil health, Global warming potential, sustainable development goals, biogas plant, bio-slurry, vermicompost, Bio Gas Plant, Vermi Pit

## 1. INTRODUCTION

A three year Innovative Project namely "Swanirvar Krishi" or "Self-Reliant Agriculture", to develop self-sustainability among the small and marginal farmers, has been undertaken under "Innovative Activity" of ATMA Scheme. The project was executed at Moraghata, Ichhapur village under Balagarh Block of Hooghly district, West Bengal, India (Latitude: 23.1753 to Longitude: 88.40017) from Rabi 2015-16 to Kharif 2018-19. The Project objectives aimed to sustainably reduce the cost of Farming System, followed throughout the year, with self-produced organic inputs by the farmers, like Biogas Plant Slurry, Vermicompost, Green Manure, or Farm Yard Manure to replace the total fertilizer requirement of the cropping sequence and round the year production of green fodder to reduce cost of animal rearing organically and sustainably through reducing the daily concentrate requirement.. At the end of three years, it has created a great deal of enthusiasm among the neighboring farmers to follow the way of farming round the year. Moreover, two successful Farming System Models under the Project have already been demonstrated under Pilot Crop D/C Programme. The Models are:

a. Producing Biogas Slurry as a by-product from Biogas Plant, as organic nutrient source, for 0.4 ha of land and growing agricultural crops as per local situation in0.27 ha of land with sole Bio-Slurry @ 6.25 t/ha in three splits and growing green fodder round the year in 0.13ha of land with same dose of Bio-slurry to rear two cows with green fodder @ 20Kg/cow/day to reduce the requirement of concentrate.
b. Producing Vermicompost for 0.4 acre of land in 192 cu ft area of Poly Vermipit, and growing agricultural crops as per local situation in 0.27ha of land with sole vermicompost @ 6.25 t/ha in three splits and growing green fodder round the year in 0.13ha of land with same dose of vermicompost to rear two cows with green fodder@ 20Kg/cow/day to reduce the requirement of concentrate.

The chosen Fodder crops are hybrid Napier, Kalai/cowpea/Sorghum/Maize, Barseem/Oat. It has been planned to grow Maize, Sorghum and cowpea in phased manner during summer and rainy season and Barseem, Maize and Oat during Rabi season. Organic cultivation has been toyed as the best ever option throughout the world, but certain issues are identified on the way of making a total shift from conventional agriculture to the organic one. The fact is that total organic shifting from conventional industrial agriculture in intensively cultivated areas may reduce the productivity (except some reports on increased productivity) at least for

initial 1-4 years and existence of large gap between available potential and utilization of organic wastes (Ramesh *et al.*, 2005). But the subsequent consequence will be sustained growth in long run.

**Project Objectives:**

a. To identify the sustainable ways to reduce the cost of farming and increase farmer's profit,
b. To improve the resource base and skill of the resource poor farmers,
c. To improve soil health organically and increase carbon sequestration to combat climate change,
d. To sustainably manage Integrated Farming System components like Agriculture, Animal Resources within the small holding size

## 2. MATERIALS AND METHODS

Seven farmers, each having 0.4 ha of land (3 bighas), were included, involving each of them for a particular model (Table 1). Of them, four individuals were supplied with seeds of fodder crops *viz.* berseem, oat and maize during *rabi*, and sorghum, maize, cowpea and cutting of hybrid napier during pre-*kharif*, and *kharif*, for growing year-round green fodder as per model. All-year-round green fodder production was undertaken by model 1 farmer in 0.07 ha (0.5 bigha /666.7 sqm.) whilst the farmers following models 2-4 individually raised the fodder crop/s in 0.13 ha (1bigha/1333.3 sqm) of land. Poly vermi pit along with vermin and a family size biogas plant was provided to the farmers as per requirement of models. Model 1 farmer raised rice crop (var. Swarna) with the application of vermicompost as basal (2.5 t $ha^{-1}$) and green manure (2.5 t $ha^{-1}$) during *kharif*, 2016. Model 2 farmer raised the same rice variety with 6.25 t vermicompost$ha^{-1}$, model 3 with Farm Yard Manure at 10.0 t $ha^{-1}$ and model 4 with biogas slurry at 6.25 t $ha^{-1}$. The Bioslurry, Vermicompost were applied in three splits(50% as basal, 25% at 15-20 DAT & 25% at 35-40 DAT) for all the models of farming where they were used and FYM was used only as basal application. The recommended dose of fertilizers (RFD), followed under Model 7, is 80:40:40 kg $N:P_2O_5:K_2O$ $ha^{-1}$ for *kharif* rice, whereas under Model 5, 75% of RFD along with 2.5 t $ha^{-1}$ vermicompost was applied. Under Model 6, vermicompost was applied @ 6.25 t $ha^{-1}$. Data were recorded on growth and grain productivity of rice crop as a part of the research project. Economic analysis of each Model was also conducted to find the profit/unit land/unit time.

**Table -1** Different model for self-Reliant Agriculture (Swanirvar Krishi)

| Model | Particulars |
|---|---|
| 1 | Growing fodder hybrid napier, kalai / cowpea, berseem/ lucerne / Gliricidia in 0.5 bigha of land to produce 20 kg green fodder $day^{-1}$ for single cow + growing *kharif* rice with 2.5 $tha^{-1}$vermicompost + 2.5 t green manure $ha^{-1}$ + *Poirakhesari*(rainfed) / *boro*rice/ potato/*khesari*/ maize/ mustard (irrigated) during *rabi*+ jute/ sesame/ moong/ maize (irrigated). |
| 2 | Growing fodder hybrid napier, kalai/cowpea, berseem / lucerne / Gliricidia in 1 bigha of land to produce 40 kg green fodder$day^{-1}$ for two cows + growing *kharif* rice with 6.25 t vermicompost $ha^{-1}$+ *Poirakhesari* (rainfed) / *boro* rice/ potato/*khesari*/ maize (irrigated) during *rabi*+ jute / sesame / moong / maize (irrigated). |
| 3 | Growing fodder hybrid napier, kalai/cowpea, berseem / lucerne / Gliricidia in 1 bigha of land to produce 40 kg green fodder $day^{-1}$ for two cows + growing *kharif* rice with 10.0 t FYM $ha^{-1}$ + *Poirakhesari* (rainfed) / *boro* rice / potato / *khesari* / maize (irrigated) during *rabi* + jute / sesame / moong / maize (irrigated). |
| 4 | Growing fodder hybrid napier,kalai/cowpea, berseem / lucerne / Gliricidia in 1 bigha of land to produce 40 kg green fodder $day^{-1}$ for two cows + growing *kharif* rice with 6.25 t biogas slurry $ha^{-1}$+ *Poirakhesari* (rainfed) / *boro*/potato/*khesari*/maize (irrigated) during *rabi*+ jute/sesame/moong/maize(irrigated). |
| 5 | Procuring vermicompost and growing *kharif* rice with 2.5 t vermicompost $ha^{-1}$+ 75% RFD +*Poirakhesari* (rainfed) / mustard/*boro* rice/potato/*khesari*/maize (irrigated) during *rabi*+ jute/sesame/moong/maize (irrigated). |
| 6 | Procuring green fodder + concentrate for two cows+ growing *kharif* rice with 6.25 t vermicompost $ha^{-1}$ +*Poirakhesari* (rainfed) / *boro* rice/potato/*khesari*/maize (irrigated) during *rabi*+ jute/sesame/moong/maize (irrigated). |
| 7 | *Kharif* rice with RFD + *Poirakhesari* (rainfed) / *boro*rice / potato /*khesari* / maize (irrigated) during *rabi*+ jute/sesame/moong/maize (irrigated) with RFDs. |

## 3. RESULTS & DISCUSSION

After three years of execution of the Project in the farmer's field at Balagarh, Hooghly, where each individual farmer was considered against each single model of farming, the recorded performances of the models have shown a very interesting result (Table-2).

Considering all the Models of farming, it has been found that Model 4 which advocates cultivating Paddy with only Bio-slurry @ 6.25 t/ha in three splits, recorded highest mean yield of 6.46 t/ha yield over three years. It has further been found that this model recorded second highest yield during Kharif 2016(5.47 t/ha) and for the next two seasons i.e Kharif 17 & Kharif 18, it recorded the highest Kharif paddy yield of 7.01 t/ha & 6.9 t/ha respectively.

Sole application of vermicompost @ 6.25 t/ha in three splits has been found to be the second best Model recording a mean yield of 6.04 t/ha over three years. As per the layout of the experimental models, two different models include sole application of vermicompost and it has been recorded that under Model 6, highest paddy yield was found in Kharif 2016 (6.22 t/ha) followed by third highest during Kharif 2017 (6.06 t/ha) & Kharif 2018 (5.85 t/ha). However for Model 2, Kharif 2017, 2018 recorded second highest yield of Kharif Paddy (6.75 t/ha & 6.1 t/ha respectively) and the mean yield over three years recorded third highest yield (6.01 t/ha). But for all the years, two models i.e sole application of Bioslurry @6.25 t/ha in three splits at basal (50%), 15-20 DAT(25%) & 35-40 DAT(25%) i.e. Model 4 and sole application of Vermicompost @6.25 t/ha in three splits at basal (50%), 15-20 DAT(25%) & 35-40 DAT(25%) i.e. Model 6 & 2 out-yielded the production of all other models including Model-7 where Recommended Dose of Chemical Fertilizer(RFD) @ 80:40:40Kg/ha of N:$P_2O_5$:$K_2O$ was applied. Model 5 recorded a mean yield of 5.48 t/ha. Model 3 recorded a mean Kharif paddy yield of 4.93 t/ha over three years.

**Table: 2** Effect of different models of farming on Kharif Paddy Yield over three years (2015-16 to 2018-19)

| Model | Kharif 2016 | Kharif 2017 | Kharif 2018 | Mean Yield (t/ha) | Remarks |
|---|---|---|---|---|---|
| **1-Green manure+Vermicompost@ 2.5 t/ha each+ Growing green fodder for one cow** | **4.80** | **0.00** | **0.00** | **4.80** | Farmer left green manuring due to mortality of dhaincha seedling owing to heavy rain related inundation. |
| **2- Vermicompost6.25 t/ha in three splits+ Growing green fodder for two cows** | **5.18** | **6.75** | **6.10** | **6.01** | |
| **3- FYM 10 t/ha at basal+Growing green fodder for two cows** | **4.73** | **4.83** | **5.23** | **4.93** | |
| **4-Bioslurry 6.25 t/ha in three splits+ Growing green fodder for two cows** | **5.47** | **7.01** | **6.90** | **6.46** | **Best treatment** |
| **5-75% Recommended Chemical fertilizer(RFD)+Procured Vermicompost2.5 t/ha** | **5.38** | **0.00** | **5.58** | **5.48** | |
| **6- Vermicompost6.25 t/ha in three splits +Procuring green fodder & concentrate for two cows** | **6.22** | **6.06** | **5.85** | **6.04** | |
| **7-RFD at 80:40:40Kg/ha N:P2O5:K2O** | **5.22** | **6.00** | **5.50** | **5.57** | |
| **Date of sowing** | 20 to-22.6.16 | 19 to-22.6.17 | 20 to-22.6.18 | | |
| **Date of Harvesting** | 7 to-10.11.16 | 5-to 8.11.17 | 5 to-10.11.18 | | |

**Table 3.** Effect of different Models on total profit per hectare during Project period (2015-16 to 2018-19)

| Model | Cost of Kharif Paddy Prodn/ ha | Cost of milk prodn/ 5 month *(Rs) | Paddy Yield (Kg/h a) | Total Paddy Prodn (Kg) | Milk Yield (Kg/5 month | Value of Kharif Paddy Prodn/ha *(Rs) | Profit/ha from Kharif paddy | Value of milk (Rs) for 5 month ** | Profit/Loss / 5 month from cows | Total Profit/ha from Kharif Paddy+ cows |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 49823 | 1175 | 4800 | 4480 | 250 | 75648 | 25826 | 6500 | 5325 | 31151 |
| 2 | 46875 | 2270 | 6010 | 5209 | 550 | 88467 | 41592 | 13000 | 10730 | 52322 |
| 3 | 43125 | 2270 | 4930 | 4273 | 315 | 72570 | 29445 | 13000 | 10730 | 40175 |
| 4 | 42915 | 2270 | 6460 | 5599 | 430 | 95091 | 52176 | 13000 | 10730 | **62906** |
| 5 | 59633 | NA | 5480 | 5480 | 0 | 92064 | 32432 | 0 | 0 | 32432 |
| 6 | 48610 | 15000 | 6043 | 6043 | 410 | 101903 | 53293 | 13000 | -2000 | 51293 |
| 7 | 56040 | NA | 5570 | 5570 | 0 | 93576 | 37536 | 0 | 0 | 37536 |

*Cost of milk production includes cost of green fodder production, cost of concentrate etc. Straw is produced by farmers, whose value (@ Rs 1.2/kg) is considered under Value from Agriculture component. Value of paddy grain is considered@ Rs 15.60/kg.

**Equal milk @ that of Model 1 is considered for Models 2, 3, 4 &6 as cows under different Models are not in same phase of lactation and the breeds of individual farmers are not same& cost /kg @ Rs 26.

While comparing the production economics of the farming models (Table 3) it has been found that model 4, where bioslurry @ 6.25 t/ha has been used as the sole source of plant nutrients both for agricultural crops and green fodder and two cows are reared with green fodder round the year without procurement of concentrate, has recorded highest economic profit/ha (Rs 62906.0) over all other models of farming. The second highest profit/ha has been recorded against farming model where vermicompost @ 6.25 t/ha is used for raising crops and green fodder and two cows were reared with green fodder without procurement of concentrate (Rs 52322.0). Model 7, where recommended fertilizer dose has only been applied, recorded a profit of Rs 37536.0/ha. Firestine *et al.* (2007) advocated using waste farm products as a renewable resource, which could reduce waste disposal costs and save money in purchasing from the local utility. Abas (2016) reported higher rice production through self-reliance on the aspects of state of mind, social affairs, technology management, natural resource management and economic affairs in case with small farmers.

## 4. CONCLUSION

The Project was an "On-Farm" research project and after three years of scheduled duration it can be concluded that Bio Slurry, a common by-product of Biogas plant, if integrated with the farming system as the sole source of plant nutrient for growing different crops at certain identified dosage and mode of application in splits, can be able to increase the profitability of the farming system sustainably. It has been found after three years of the Project that farming model with crop production through bioslurry management at specific dose and mode of application along with rearing two cows with own-produced green fodder(M-4) has recorded 67.59% more profit over model with application of recommended dose of chemical fertilizer only(M-7)(Table -3). Besides Bioslurry, another important indigenous input that has been identified under this project is vermicompost. Maintaining the same dose and mode of application as that of bioslurry, vermicompost can also effectively reduce cost of cultivation and increase farmer profit sustainably. It has been found that farming model with crop production through vermicompost along with rearing cows through own produced green fodder (M-2) has recorded 39.39% profit over farming model with recommended fertilizer dose only (M-7).

Moreover, the usefulness of biogas to considerably reduce or replace the requirement of polluting and or subsidized cooking fuels like wood, cow dung cake, kerosene or LPG in rural areas will be another value addition of the farming system using bioslurry. This will effectively and sustainably reduce the cost of living in rural areas and increase the use of green energy and help in effective rural waste management. Finally, as a Family size Biogas Plant producing 2-3 cft gas per day is recorded to have Global Warming Mitigation Potential @ 9.7 t $CO_2$ equivalent/year, this model of farming can also help the country to combat Global Warming and meet the declared Sustainable Development Goals(SDGs) of the country (Pathak H, 2009). FAO has targeted to make the world hunger-free by 2030 and for that reason focused on sustainable farming technologies that can improve production at local level.

The "On-farm' project on "Swanirvar Krishi" has helped to identify such effective sustainable farming technologies to help to increase the production, productivity & profitability of the farming system at local level with active participation of the local people and upgrading their skill & village resource base. Basically, it helps to identify and develop sustainable agricultural tools for small and marginal farmers as well as consumers to think globally and act locally.

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**Conflict of Interest:**
The authors declare that there are no conflicts of interests.

**Peer-review:**
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**Data and materials availability:**
All data associated with this study are present in the paper.

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